Seven Pillars of Ecosystem Management

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Abstract

Ecosystem management is widely proposed in the popular and professional literature as the modern and preferred way of managing natural resources and ecosystems. Advocates glowingly describe ecosystem management as an approach that will protect the environment, maintain healthy ecosystems, preserve biological diversity, and ensure sustainable development. Critics scoff at the concept as a new label for old ideas The definitions of ecosystem management are vague and clarify little. Seven core principles, or pillars, of ecosystem management define and bound the concept and provide operational meaning: (1) ecosystem management reflects a stage in the continuing evolution of social values and priorities; it is neither a beginning nor an end; (2) ecosystem management is place-based and the boundaries of the place must be clearly and formally defined; (3) ecosystem management should maintain ecosystems in the appropriate condition to achieve desired social benefits; (4) ecosystem management should take advantage of the ability of ecosystems to respond to a variety of stressors, natural and man-made, but all ecosystems have limited ability to accommodate stressors and maintain a desired state; (5) ecosystem management may or may not result in emphasis on biological diversity; (6) the term sustainability, if used at all in ecosystem management, should be clearly defined — specifically the time frame of concern, the benefits and costs of concern, and the relative priority of the benefits and costs; and (7) scientific information is important for effective ecosystem management, but is only one element in a decision-making process that is fundamentally one of public and private choice. A definition of ecosystem management based on the seven pillars is: "The application of ecological and social information, options, and constraints to achieve desired social benefits within a defined geographic area and over a specified period." As with all management paradigms, there is no "right" decision but rather those decisions that appear to best respond to society's current and future needs as expressed through a decision-making process. There are, however, wrong management decisions, including the decision not to make a decision.

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Introduction

Ecosystem management, proposed as the modern and preferred way of managing natural resources and ecosystems, is a bold concept:

> *Ecosystem management defines a paradigm that weaves biophysical and social threads into a tapestry of beauty, health, and sustainability. It embraces both social and ecological dynamics in a flexible and adaptive process. Ecosystem management celebrates the wisdom of both our minds and hearts, and lights our path to the future.* (Cornett, 1994)

When implemented, ecosystem management will, at least according to its advocates, protect the environment, maintain healthy ecosystems, permit sustainable development, preserve biodiversity, and save scarce tax dollars. A cynic might be tempted to add to the list: alleviate trade imbalances, reduce urban crime, and pay off national debts. Is ecosystem management a revolutionary concept and a sea change in public choice as its champions maintain, or are the critics right who assert that it and the associated jargon are closer to cold fusion than cold fact?

Whether ecosystem management is "hot tub science applied to New Age management" -- or "a paradigm shift to save our rapidly disappearing biological heritage" -- scientists and managers are increasingly involved in the debate. Why should scientists and other technical people care about ecosystem management as a concept or follow the spirited debates over its exact meaning? For at least three reasons: *first*, the concept has been embraced widely by politicians and appointed officials. At least in the political arena, the debate is concluded whether or not ecosystem management is a good idea; it *will* be implemented, or at least attempted, in word if not in deed.

Second, it might just be a bold new concept and a very different -- and better -- way of managing ecosystems. Beyond the rhetoric, there may in fact be some technical substance. Ideas do have consequences -- especially those that are put into practice on a wide scale.

Third, society needs to move beyond the debates over rhetoric and focus directly on policy issues and the role science could and should play. There are a considerable number of interesting and challenging research opportunities on ecosystems, but what are the *critical* research needs and management approaches that will make a *difference* in ecosystem management?

Ecosystem management is offered as a management approach to help solve complex ecological and social problems. Examples of current problems are the Pacific Northwest forest/salmon/spotted owl impasse; the purported massive decline in biological diversity; and ecosystem "degradation" caused by "poor" urban, industrial, transportation, agricultural, ranching, and mining policies and practices. Some critics may charge that ecosystem management is the triumph of the politics of "process" over the politics of "substance," but the public choice problems are definitely real and substantive.

Ecosystem management problems have several general characteristics: (1) fundamental public and private values and priorities are in dispute, resulting in partially or wholly mutually exclusive decision alternatives; (2) there is substantial and intense political pressure to make rapid and significant changes in public policy; (3) public and private stakes are high, with substantial costs and substantial risks of adverse effects (some also irreversible ecologically) to some groups regardless of which option is selected; (4) the technical facts, ecological and sociological, are highly uncertain; (5) the "ecosystem" and "policy problems" are meshed in a large framework such that policy decisions will have effects outside the scope of the problem. Solving these kinds of problems in a democracy has been likened to asking a pack of four hungry wolves and a sheep to apply democratic principles to deciding what to eat for lunch. Given public choice problems with these characteristics, no wonder discussions of ecosystem management tend to focus on *process* and not *substance.*

The purpose of this article is to summarize my views of ecosystem management. The views are my own; they do not necessarily reflect the views of any organization. Reviews of earlier drafts of this paper have convinced me that my views may not even represent the views of many of my peers. The range of opinions on ecosystem management is wide.

I have organized the fundamental concepts of ecosystem management around seven *pillars* which I consider to be the supports underlying ecosystem management. Just as physical pillars do not completely define a building, neither do intellectual pillars completely define ecosystem management. Nevertheless, I hope that these pillars effectively provide the essential underpinnings of “ecosystem management,” the circumstances under which it might be successfully applied, and its relationship to public and private choice. The seven pillars are neither procedures nor blueprints for ecosystem management but are principles upon which ecosystem management should be based. T. E. Lawrence found his seven pillars amidst the chaos of revolution; the pillars of ecosystem management will more likely be found in the diverse literature on the subject.

Definition

Articulating a clear *definition* for ecosystem management seems a reasonable place to start. The diversity of definitions provides some indication of the current amorphous nature of the concept (Norton, 1992; Slocombe, 1993; Bengston, 1994; Stanley, 1995). Typical of definitions of ecosystem management are:

1. "A strategy or plan to manage ecosystems to provide for all associated organisms, as opposed to a strategy or plan for managing individual species" (FEMAT, 1993).

2. "The careful and skillful use of ecological, economic, social, and managerial principles in managing ecosystems to produce, restore, or sustain ecosystem integrity and desired conditions, uses, products, values, and services over the long term" (Overbay, 1992).

3. "To restore and maintain the health, sustainability, and biological diversity of ecosystems while supporting sustainable economies and communities" (EPA, 1994).

These definitions have an unmistakable similarity to traditional definitions of fisheries management, wildlife management, and forest management. In fact, they are strikingly similar to the much maligned definition of multiple use management. For example, a typical definition of fisheries management is the "practice of analyzing, making, and implementing decisions to maintain or alter the structure, dynamics, and interaction of habitat, aquatic biota, and man to achieve human goals and objectives through the aquatic resource" (Lackey, 1979). But in the definitions of ecosystem management, there are some new words -- *ecosystem and community sustainability, ecosystem health, ecosystem integrity, biological diversity, social values, social principles.* The new words are where differences arise and it is from these words that I will develop the pillars.

Values and Priorities

What does society want from ecosystems? There are two fundamentally different world views (Lackey, 1994; Stanley, 1995). The first is *biocentric* and considers maintenance of ecological health or integrity as the goal. All other aspects, including man's use (tangible or intangible) are of secondary consideration. The other view is *anthropocentric* in that benefits (tangible or intangible, short and long-term) are accruable to man. Certainly the ecological systems can be adversely affected and care should be taken not to deplete resources for short-term benefit, but sustainable benefits are possible from ecosystems with careful management. Neither view is necessarily right or wrong, but they are fundamentally different views and must be evaluated like any other moral or religious position.

The basic idea behind a management paradigm is anthropocentric; it is to maximize benefits by applying a mix of decisions within defined constraints. Benefits may be tangible or intangible and may be achieved by maintaining a desired ecological condition. Potential benefits from ecosystems may be commodity yields (lumber, fish, wildlife), ecological services (pollution abatement, biological diversity), intangibles (preservation of endangered species, wilderness, vistas), precautionary investments (deferring use to preserve future options), and maintaining a desired ecological status (old growth forests, unaltered rangelands). The management challenge is to figure out what the *goal* or *goal set* is and then design a strategy for implementing a *mix* of decisions to reach the goal (Bormann, 1994). A key challenge to successful management is accurately determining the system's capacity to achieve that goal -- an important challenge that scientists can help meet.

The first and foremost management challenge, figuring out exactly what *is* the goal, is complicated by the evolving nature of society's values and priorities. It is difficult to be concerned with an endangered toad or a threatened snail when your family's immediate problem is surviving the winter. And it is difficult to understand the passion for industrial development when your major concern is whether you will take a vacation this winter or wait until summer. Our individual and collective goals and values differ with our circumstances and change over time.

The other management challenge involves evaluating and selecting the mix of decisions that seem likely to achieve the identified goal -- a goal which must be continually evaluated to be sure that it reflects society's values and priorities. This is no easy task under the best of circumstances, but it becomes impossible unless the analyst at least *assumes* a matrix of societal goals. The most efficient way to implement policy may be through a series of "experimental" decisions from which we can "learn" how the ecosystem (ecological and human elements) responds to various decisions. A modification of an old maxim may be most appropriate here: "the best way to implement ecosystem management may be to learn from past mistakes and also systematically make some new but different ones."

The important central role of values and priorities has long been recognized in management. Management paradigms, whether they be multiple use, multiple resource use, maximum equilibrium yield, scientific management, watershed management, natural resources management, maximum sustained yield, or ecosystem management are based on values and priorities (Cubbage and Brooks, 1991). Each paradigm has either, formally or informally, accepted a set of values and priorities, or used a process to derive values and priorities. Ecosystem management is no different in this regard.

The first pillar of ecosystem management is:

Ecosystem management reflects a stage in the continuing evolution of social values and priorities; it is neither a beginning nor an end.

Boundaries

A practical technical requirement with any management paradigm is to *bound* the system of concern. Because no useable definition of an ecosystem has been developed that works within public decision-making, other approaches are used to define the "system" of concern. Historically, this was accomplished by focusing on one or more species of concern over a defined geographic area. We manage flyways for migratory waterfowl, for example. The geographic limits of the flyway become the operational boundaries for the management analysis. Or we manage the game fish populations in a certain lake. The lake and its watershed then become the unit of concern. In all cases the "problem" of concern will define the boundary.

Another option is to bound the system by what is relevant to elements of the public such as a community or interest group. For example, management goals might focus on providing diverse hunting options to society. However, no matter how boundaries are defined in ecosystem management, they end up largely being geographically based -- a *place* of concern. Again the nature of the problem or the beneficiaries of concern will define the boundaries.

Within the place of concern the goal then becomes managing for maximum social benefits within a number of ecological and societal constraints. And because management optima vary by the scale of consideration, it is essential to define clearly the boundary of concern. For example, a set of decisions to maximize benefits in managing a 1,000-hectare watershed *within* the Columbia River watershed may well be very different than decisions for the same smaller watershed that were designed to maximize benefits over the *entire* Columbia River watershed. The definition of the management problem should define the scale to be used in the analysis. The same problems analyzed at different scales will likely lead to very different management strategies.

There is a natural tendency to gloss over decisions on boundaries because deciding on boundaries explicitly defines the management problem. In a pluralistic society, with varied and strongly held positions, conflict is intensified when perceptive individuals and groups immediately see how their position may be weakened by a certain choice of boundaries. However, not to define boundaries will lead to management strategies that lack intellectual rigor, or will result in debates over technical issues when the debates are really clashes over values and priorities.

The second pillar of ecosystem management is:

Ecosystem management is place-based and the boundaries of the place of concern must be clearly and formally defined.

Health

The terms ecological *health* and ecological *integrity* are widely used in scientific and political lexicon (Rapport, 1989; Costanza, et al., 1992; Norton, 1992; Grumbine, 1994). Politicians and many political advocates widely argue for managing ecosystems to achieve a "healthy" state or to maintain ecological "integrity." By implication their opponents are relegated to managing for "sick" ecosystems.

Scientists often speak and write about monitoring the health of ecosystems, or perhaps the integrity of the ecosystem. There is usually the assumption that there is an *intrinsic* state of health or integrity and other, lesser states of health or integrity for any given ecosystem (Norton, 1992). Some scientists explicitly advocate " . . . that maintaining ecosystem integrity should take precedence over any other management goal" (Grumbine, 1994).

Much of the general public seems to accept that there must be a technically defined healthy state similar to their personal human health. After all, people know how they feel when they are sick, and so, by extension, ecosystem sickness must be a similar condition, which should be avoided. "Health" is a powerful metaphor in the world of competing policy alternatives.

For example, society may wish to manage a watershed to maximize opportunities for viewing the greatest possible diversity of birds, for the greatest sustained yield of timber, or for the greatest sustained yield of agricultural products. Achieving each goal would almost assuredly result in ecosystems that were very different, but equally "healthy."

The debate is really over defining the "desired" state of the ecosystem, and secondarily, managing the ecosystem to achieve the desired state. Phrased another way: What kind of garden does society want (Regier, 1993)? There is no intrinsic definition of health without a benchmark of the desired condition. In ecosystem management, scientists should avoid value-laden terms such as "degradation, sick, destroy, safe, exploitation, collapse, and crisis" unless they are accompanied with an explicit definition of what the desired condition of the ecosystem is as defined by society. The word "society," as used here, includes only humans.

In philosophical terms, the problem with "health" is how one links "is" and "ought." For example, an ecosystem has certain characteristics -- these are facts on which all analysts who study the ecosystem should be able to agree. Characteristics such as species diversity, productivity, and carbon cycling are examples. If the same definitions and the same methods are used, all analysts should come to the same answer within the range of system and analytical variability. The "ought" must involve human judgment -- it cannot be determined by scientific or technical analysis (Shrader-Frechette and McCoy, 1993). The concept of "health" has a compelling appeal, but it has no operational meaning unless it is defined in terms of the *desired* state of the ecosystem.

The third pillar of ecosystem management is:

> *Ecosystem management should maintain ecosystems in the appropriate condition to achieve desired social benefits; the desired social benefits are defined by society, not scientists.*

Stability

Stability, resilience, fragility, and *adaptability* are interesting and challenging concepts in ecology. These are some of the characteristics of ecosystems that provide an opportunity to realize benefits for society, but these same characteristics constrain options for society and the ecosystem manager. Stability and the related concepts are very difficult to describe clearly because of the variations in definition for all the terms associated with this topic. Particular care must be taken to be sure that differences in opinion are not due to differences in definition.

There is a widespread, if sometimes latent, view that ecosystems are best that have not been altered by man. Further, it just seems obvious that such "healthy" ecosystems *must* be more stable than the altered, less "healthy" ones, just as the Romantic School held that nature realized its greatest perfection when not affected by man. This is the classic "balance of nature" view. Pristine is good; altered is bad -- perhaps necessary for food, lodging, or transport, but still not as desirable as pristine. However, few seem to be willing to return to the "natural" human mortality rates of at least 50% from birth to age five.

Moreover, this is not how nature works (Kaufman, 1993). There is no "natural" state in nature; it is a relative concept. The only thing natural is change, sometimes somewhat predictable, oftentimes random, or at least unpredictable. It would be nice if it were otherwise, but it is not. The concept of dynamic equilibrium might place bounds on ecosystem change in an intellectual attempt to describe better stability, but the intuitive appeal of the concept of stability is not easily fulfilled. Some ecologists cling to traditional concepts of stability and equilibrium with a near missionary zeal.

Ecosystems are resilient, although not without limits. A key role of science in ecosystem management is to identify the limits or constraints that bound the options to achieve various societal benefits. The trick in management is to balance the ability of ecosystems to respond to stress (including use or modification) in desirable ways, but without altering the ecosystem beyond its ability to provide those benefits. We want shelter, food, personal mobility, energy, etc., but we do not want the systems to collapse that are producing those benefits.

The fourth pillar of ecosystem management is:

Ecosystem management can take advantage of the ability of ecosystems to respond to a variety of stressors, natural and man-made, but there is a limit in the ability of all ecosystems to accommodate stressors and maintain a desired state.

Diversity

The level of *biological diversity* in an ecosystem is an important piece of scientific information, and this knowledge can be useful in understanding the *potential* of an ecosystem to provide certain types of social benefits. Grumbine (1994) argued that ecosystem management is a response to today's deepening biodiversity crisis. This may be true *politically*, but biological diversity is purely a technical piece of information. What people value about biotic resources, whether biological diversity or something else, is not a technical question.

An argument often made is that biological diversity is necessary to maintain ecosystem stability. This argument contains an element of truth, but there is only the most general linkage between biological diversity and ecosystem stability (Goodman, 1975; Shrader-Frechette and McCoy, 1993). Like any other attribute of ecosystems, the value of biological diversity to society must be based on society's preferences. That is not to say that biological diversity (and many other characteristics of ecosystems) is not important; it is. But, as a characteristic of ecosystems, biological diversity operates as an *ecological constraint*, not as a *benefit -- unless there is an explicit societal preference*. Many people's values clash over biological diversity, but that is a human preference issue; the ecological role and function of biological diversity is purely a technical question.

It is possible, even likely, that society may value elements of biological diversity as social benefits in and of themselves, but this is a public choice, not a scientific one (Trauger and Hall, 1992). For example, public choice may dictate that no naturally occurring species go extinct due to human action. This is certainly a legitimate social benefit, but not a scientific one. Biological diversity may or may not have intrinsic worth to society.

There are other fundamental public choice issues involved with biological diversity: Do you consider all species, exotic or otherwise, as part of the fauna and flora for the purposes of assessing biological diversity? Is not every species an exotic? What scale do you use to measure diversity? By some measures diversity has increased; by others it has decreased (Berryman, 1991). The choice of the scale used and whether you include exotic species will primarily answer whether biological diversity is increasing or decreasing.

If the public expresses a social preference for biodiversity in its *own right,* then do our management options include increasing biological diversity beyond what would naturally occur? Should we reintroduce extirpated species (or introduce exotic species) to increase diversity? Should we use the tools of genetic engineering to double or triple biological diversity? Producing agricultural crops with high performance seeds is not natural, so why not use tools like genetic engineering to increase biological diversity if it is a social benefit?

The fifth pillar of ecosystem management is:

Ecosystem management may or may not result in emphasis on biological diversity as a desired social benefit.

Sustainability

Sustainability and a host of related concepts are important elements of nearly all management paradigms. There is a considerable literature on defining exactly what these concepts actually mean and whether the concepts, however defined, are really relevant with changing social priorities and technology. There is always considerable debate over whether various societal benefits (including ecosystem "harvests" or outputs) are sustainable, but historically the basic goal has almost always been to produce sustainable outputs of something, tangible or intangible. Sustainable *tangible* outputs (fish, deer, visitor days, drinking water, lumber) are much easier to identify and measure than are the more *intangible* benefit yields (ecosystem integrity, biodiversity, endangered species) typical in ecosystem management. However, whether "yields" of benefits are described and measured in trees, fish, deer, visitor days, diversity of recreational opportunity, or maintenance of "wilderness areas that no one visits," all are realized *benefits* accruable to man. Benefits are produced within constraints and ecosystems, like all systems, have constraints.

Much more tenuous is the analytical basis for sustainable development -- a term often used interchangeably, but inappropriately, with sustainability. The goal of sustainable development typically offered is ". . . to meet the needs of the present without compromising the ability of future generations to meet their own needs," or in economic terms as exemplified in the 1993 Presidential Executive Order on sustainability, " . . . economic growth that will benefit present and future generations without detrimentally affecting the resources or biological systems of the planet." The concept of sustainable development masks some fundamental policy conflicts that mere word-smithing will not alleviate (Norton, 1991, Goodland, et. al, 1993). If one assumes existing social values and priorities, increasing human population, and constant technology, then we cannot *develop* in perpetuity. By necessity we must assume that either values and priorities will change and/or technology will change; otherwise, sustainable development is an oxymoron (Dovers and Handmer, 1993). There are precise definitions of "develop" that have been offered to counter the logical inconsistencies in the concept of sustainable development; however, at least in the way sustainable development is typically used in public and political rhetoric, the inconsistencies remain. More defensible is the concept of environmental sustainability which, although logically consistent, leads inevitably to painful choices for society (Goodland et al., 1993). Natural resource management has a long history of failures, in part due to the use of management "magic": the willingness to promise management success when simple logic leads to the opposite conclusion (Ludwig, 1993).

Selecting *what* is to be sustained is a societal choice which should be expected to change over time (Kennedy, 1985; Gale and Cordray, 1991). Do we measure sustainability of commodity yields as surrogates for total societal benefit? Do we measure sustainability of the ecosystem in some defined state? Over what time frames do we measure sustainability? A generation? Over 50 years? Over 100 years? A millennium? What is the scale of sustainability? A small watershed? An ecoregion? The entire nation? How is sustainability to be measured when societal values and priorities change? In short, sustainability often raises more questions than it answers.

Further complicating the concept of sustainability is the apparent chaotic characteristic of ecosystems. Sustainability is often based, at least tacitly, on a largely homeostatic view of nature -- that is, there is a certain natural condition of an ecosystem or perhaps a trajectory of change. But there is no natural state of any ecosystem, only conditions from a wide array of possibilities, known and unknown. The term "balance of nature" has passed out of common usage in ecology, and this reflects the acceptance, albeit reluctant, of the essentially chaotic nature of ecosystems.

The sixth pillar of ecosystem management is:

The term sustainability, if used at all in ecosystem management, should be clearly defined –– specifically, the time frame of concern, the benefits and costs of concern, and the relative priority of the benefits and costs.

Scientific Information

Some level of ecological understanding and *information* specific to the ecosystem of concern is essential to effective ecosystem management. The question is how much understanding and information is needed. After all, it is the ecological characteristics of ecosystems that largely constrain various management options to produce societal benefits.

Other types of information are also important; for example, knowing how individuals and groups might respond to various decision options (Ludwig et al., 1993). Tax incentives may be an especially important tool in ecosystem management, so a solid understanding of how people will respond to modifications in tax law is essential. Erroneous predictions of individual and group response to regulations, policies, or other regulatory tactics are all too common in policy analysis.

Scientific information is by its nature uncertain -- sometimes highly uncertain. Often scientific information and predictions based on scientific information can become the lightning rod for debate over various management options. Debate over values and priorities is important and should be encouraged in the public and policy arena; this is not, however, the most appropriate arena to debate scientific information. It is important to isolate the two types of debates.

Part of the responsibility for the confusion over "providing information" vs. "advocating policy" rests with scientists. Many ecologists have a strong tendency to support "environmentalist" worldviews and positions. This is understandable in part due to self selection in all professions (environmentally oriented individuals are more likely to select ecologically oriented fields than are more materially oriented individuals). The same self selection takes place in business management (business oriented individuals are prone to select an MBA program rather than a Master of Science program in conservation biology). Individuals in any profession naturally tend to be advocates for what is important in that profession. It is easy to understand the difficulty that many ecologists have in deleting from their scientific vocabularies such value-laden and emotionally charged words as "sick, "healthy," and "degraded." Language is not neutral and we should be very careful when speaking as *scientists. Scientists should also avoid unspoken assumptions that reflect value-laden or emotionally based opinions.*

The seventh pillar of ecosystem management is:

Scientific information is important for effective ecosystem management, but is only one element in a decision-making process that is fundamentally one of public or private choice.

Conclusion

Where do these pillars leave us? The seven pillars of ecosystem management collectively define and bound the concept of ecosystem management. Whether the concept turns out to be useful will depend on how well its application reflects a collective societal vision. Whether it is possible to develop a collective societal vision in a diverse, multicultural, polarized society such as ours is a major, and yet to be answered, question. The democratization of science, policy, and choice is not a smooth process, nor will it ever be efficient.

At least in North America the ideas behind ecosystem management represent a predictable response to evolving values and priorities. Those values and priorities will continue to evolve, although the direction and degree of their evolution are ambiguous and largely unpredictable. Without major social jolts such as war, economic collapse, the return of plagues, or natural disasters, the movement of social preferences toward values and priorities of the affluent will probably continue. Such values and priorities operate in the seemingly paradoxical world of intensive use and alteration of nearly all ecosystems, while at the same time, high value is given to the non-consumptive elements of ecosystems such as pristineness. We may want the benefits and affluence of a "developed" economy, but we do not want its factories, foundries, and freeways in our back yard.

There are other directions for ecosystem management that are less clear, but potentially much more significant. At a recent conference a statement was made that illustrates such a possible direction: "It is time to change our [society's] charter with individuals. We have massive and critical problems with our ecosystems that cry out for immediate action because we have subordinated the collective good of society to the will of individuals. Personal freedom must be weighed against the harm it has caused to the whole of society and more importantly to our ecosystems." A response to the statement was equally instructive: "Society and freedom are at greatest risk from those with the noblest of agendas."

Ecosystem management will continue to be place-based. Ecosystem management problems need to be bounded to make them tractable. A practical implementation problem is that much of the "place" is owned by individuals, not by society in the form of "public lands." By being place-based, application of ecosystem management will become a lightning rod for debates over individual vs. societal "rights." How does society balance the rights of individuals not to have their property taken without compensation against the right of society, collectively, to prosper? Or perhaps the concept of owning ecosystems (places) must yield to other "rights" for the greater collective good?

At a superficial level the role of scientific information will continue to become more prominent in ecosystem management. However, most of the really important decisions are choices among competing and often mutually exclusive values. The role of scientific information is important, but it does not substitute for choices among values.

Ecosystem health, ecosystem integrity, biodiversity, and sustainability have evolved from scientific terms to terms used in debates over values. Unless these terms are precisely defined and clearly separated from values and priorities, their value in science is severely diminished. There are major differences in the concepts of sustainability, sustainable development, and developments that are sustainable, but the differences are not easy to explain and understand in the world of sound byte politics. I recommend that they be dropped from use in scientific discourse and that more precise, nonvalue-laden terms be used. Scientists need to be involved throughout the process of ecosystem management, but in a clearly defined, interactive role where the values and priorities of the public are implemented, not those of scientists.

The definition of ecosystem management is:

> *The application of ecological and social information, options, and constraints to achieve desired social benefits within a defined geographic area and over a specified period.*

In conclusion, ecosystem management is not a revolutionary concept nor an oxymoron, but rather an evolutionary change from existing, well-established paradigms. What is revolutionary is the fact that the issues have moved from the hallways of obscure bureaucracies and remote academic outposts to the political landscape. For better or worse, ideas do make a difference.

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Author Bio

Dr. Robert T. Lackey, senior fisheries biologist at the U.S. Environmental Protection Agency's research laboratory in Corvallis, Oregon, is also courtesy professor of fisheries science and adjunct professor of political science at Oregon State University. Since his first fisheries job over four decades ago mucking out raceways in a trout hatchery, he has dealt with a range of natural resource issues from positions in government and academia. His professional work has involved many areas of natural resource management and he has written 100 scientific and technical journal articles. His current professional focus is providing policy-relevant science to help inform ongoing salmon policy discussions. Dr. Lackey also has long been active in natural resources education, having taught at five North American universities. He continues to regularly teach a graduate course in ecological policy at Oregon State University and was a 1999-2000 Fulbright Scholar at the University of Northern British Columbia. A Canadian by birth, Dr. Lackey holds a Doctor of Philosophy degree in Fisheries and Wildlife Science from Colorado State University, where he was selected as the 2001 Honored Alumnus from the College of Natural Resources. He is a Certified Fisheries Scientist and a Fellow in the American Institute of Fishery Research Biologists.

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